DECLARATION

I, SHINICHI USUI, a Japanese Patent Attorney registered No. 9694, of Okabe International Patent Office at No. 602, Fuji Bldg., 2-3, Marunouchi 3-chome, Chiyoda-ku, Tokyo, Japan, hereby declare that I have a thorough knowledge of Japanese and English languages, and that the attached pages contain a correct translation into English of the priority documents of Japanese Patent Application No. 2000-063399 filed on March 8, 2000 in the name of CANON KABUSHIKI KAISHA.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that wilful false statements and the like so made, are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such wilful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed this 26th day of June, 2003

SHINICHI USUI

PATENT OFFICE
JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this office.

Date of Application: March 8, 2000

Application Number: Japanese Patent Application No. 2000-063399

Applicant(s): CANON KABUSHIKI KAISHA

April 14, 2000

Commissioner,
Patent Office TAKAHIKO KONDO

(Seal)
Certificate No. 2000-3027117

[Name of the Document]	Patent Application
[Reference No.]	4174041
[Date]	March 8, 2000
[Addressed to]	Commissioner of the Patent Office
[International Classification]	G02B 26/10
[Title of the Invention]	Multibeam Scanning Optical Apparatus and Color Image-forming Apparatus
[Number of the Claims]	67

[Inventor]

[Domicile or Residence]	c/o Canon Kabushiki Kaisha 30-2, 3-chome, Shimomaruko, Ohta-ku, Tokyo
[Name]	MANABU KATO

[Applicant]

[Identification No.]	000001007
[Name]	CANON KABUSHIKI KAISHA
[Representative]	FUJIO MITARAI

[Attorney]

[Identification No.]	100086818
[Patent Attorney]	
[Name]	YUKIO TAKANASHI

[Claim to Priority Based on the Earliest Application(s)]

[Application No.]	No. 11-66536
[Application Date]	March 12, 1999

[Indication of Official Fee]

[Prepayment Ledger No.]	009623
[Amount]	21000

[List of Filed Materials]

[Material]	Specification	1
[Material]	Drawings	1
[Material]	Abstract	1
[General Power of Attorney]	9703877	

[Proof requirement] necessary

CFO14341

2000-63399

[Name of the Document] Specification

[Title of the Invention] Multibeam Scanning Optical Apparatus and Color Image-forming Apparatus

[Claim(s)]

[Claim 1] A multibeam scanning optical apparatus which leads a plurality of light beams modulated and emitted independently relative to each other from a light source having a plurality of light beam emitting sections and scans a surface to be scanned by a plurality of said light beams, wherein

the timing of the start of scanning in the main scanning direction is controlled at or near the center of the scanning width in the main scanning direction on said surface to be scanned.

[Claim 2] A multibeam scanning optical apparatus according to claim 1, wherein the timing of the start of scanning in the main scanning direction is controlled for a plurality of light beams emitted from a plurality of said light beam emitting sections.

[Claim 3] A multibeam scanning optical apparatus which leads a plurality of light beams modulated and emitted independently relative to each other from a light source having a plurality of light beam emitting sections and scans a surface to be scanned by a plurality of said light beams, comprising:

a first optical element for converging a plurality of light beams emitted from said light source to substantially collimated light beams;

a second optical element for focusing a plurality of said substantially collimated light beams converted as a longitudinal linear image in the main scanning direction on a deflection surface of a defection element;

a third optical element for focusing a plurality of light beams deflected by said deflection element on the surface to be scanned; and

synchronism detection means for controlling the timing of the start of scanning on said surface to be scanned using some light beams for synchronism detection among a plurality of light beams deflected by said deflection element, wherein

the synchronism detecting optical element is provided in an optical path between said deflection element and said synchronism detection means and the optical plane of said synchronism detecting optical element is arranged substantially orthogonal relative to said synchronism detection light beams, and

the timing of the start of scanning in the main scanning direction is controlled at or near the center of the scanning width in the main scanning direction on said surface to be scanned.

[Claim 4] A multibeam scanning optical apparatus

according to claim 3, wherein said synchronism detecting optical element comprises an anamorphic lens.

[Claim 5] A multibeam scanning optical apparatus according to claim 3 or 4, wherein said synchronism detecting optical element is made of a plastic material.

[Claim 6] A multibeam scanning optical apparatus according to claim 3, wherein said third optical element has a refraction optical element and a diffraction optical element.

[Claim 7] A multibeam scanning optical apparatus according to claim 6, wherein the refraction optical element and the diffraction optical element of said third optical element are made of a plastic material.

[Claim 8] A multibeam scanning optical apparatus according to claim 7, wherein said synchronism detecting optical element and the refraction optical element of said third optical element are integrally formed by using the plastic injection molding.

[Claim 9] A multibeam scanning optical apparatus according to claim 3, wherein said synchronism detecting optical element and said second optical element are integrally formed by using the plastic injection molding.

[Claim 10] A multibeam scanning optical apparatus according to any one of claims 3 to 9, wherein said synchronism detection means controls the timing of the start of scanning in the main scanning direction for a

plurality of light beams emitted from a plurality of said light beam emitting sections respectively.

[Claim 11] A color image forming apparatus which has a plurality of pairs between a scanning optical apparatus and an image carrier corresponding thereto, leads said light beams emitted from the scanning optical apparatuses to the corresponding image carrier surfaces, scans said image carrier surfaces using said light beams, forms images with different light colors on said image carrier surfaces, and forms a color image based on the images formed on a plurality of said image carrier surfaces, wherein

a plurality of said scanning optical apparatuses control the timing of the start of scanning in the main scanning direction at or near the center of the scanning width in the main scanning direction on said image carrier surface.

[Claim 12] A color image forming apparatus which has a plurality of pairs between a scanning optical apparatus and an image carrier corresponding thereto, leads said light beams emitted from the scanning optical apparatuses to the corresponding image carrier surfaces, scans said image carrier surfaces using said light beams, forms images with different light colors on said image carrier surfaces, and forms a color image based on the images formed on a plurality of said image carrier surfaces,

and each of a plurality of said scanning optical apparatuses comprises:

light source means comprising semiconductor laser;

a first optical element for converging a plurality of light beams emitted from said light source to substantially collimated light beams;

a second optical element for focusing a plurality of said substantially collimated light beams converted as a longitudinal linear image in the main scanning direction on a deflection surface of a defection element;

a third optical element for focusing a plurality of light beams deflected by said deflection element on the image carrier surfaces; and

synchronism detection means for controlling the timing of the start of scanning on said image carrier surfaces using some light beams for synchronism detection among a plurality of light beams deflected by said deflection element, wherein

the synchronism detecting optical element is provided in an optical path between said deflection element and said synchronism detection means and the optical plane of said synchronism detecting optical element is arranged substantially orthogonal relative to said synchronism detection light beams, and

the timing of scanning in the main scanning direction is controlled at or near the center of the

scanning width in the main scanning direction on said image carrier surface.

[Claim 13] A color image forming apparatus according to claim 12, wherein said synchronism detecting optical element comprises an anamorphic lens.

[Claim 14] A color image forming apparatus according to claim 12 or 13, wherein said synchronism detecting optical element is made of a plastic material.

[Claim 15] A color image forming apparatus according to claim 12, wherein said third optical element has a refraction optical element and a diffraction optical element.

[Claim 16] A color image forming apparatus according to claim 15, wherein the refraction optical element and the diffraction optical element of said third optical element are made of a plastic material.

[Claim 17] A color image forming apparatus according to claim 16, wherein said synchronism detecting optical element and the refraction optical element of said third optical element are integrally formed by using the plastic injection molding.

[Claim 18] A color image forming apparatus according to claim 12, wherein said synchronism detecting optical element and said second optical element are integrally formed by using the plastic injection molding.

[Claim 19] A color image forming apparatus which

has a plurality of pairs between a scanning optical apparatus, including light source means having a plurality of light beam emitting sections, and an image carrier corresponding thereto, leads a plurality of light beams modulated and emitted independently relative to each other from the scanning optical apparatuses to the corresponding image carrier surfaces, scans said image carrier surfaces using a plurality of said light beams, forms images with different light colors on said image carrier surfaces, and forms a color image based on the images formed on a plurality of said image carrier surfaces, wherein

a plurality of said scanning optical apparatuses control the timing of the start of scanning in the main scanning direction at or near the center of the scanning width in the main scanning direction on said image carrier surface.

[Claim 20] A color image forming apparatus according to claim 19, wherein each of the timing of the start of scanning in the main scanning direction for a plurality of light beams emitted from a plurality of said light beam emitting sections respectively is controlled.

[Claim 21] A color image forming apparatus which has a plurality of pairs between a scanning optical apparatus and an image carrier corresponding thereto, leads said light beams emitted from the scanning

optical apparatuses to the corresponding image carrier surfaces, scans said image carrier surfaces using said light beams, forms images with different light colors on said image carrier surfaces, and forms a color image based on the images formed on a plurality of said image carrier surfaces,

and each of a plurality of said scanning optical apparatuses comprises:

light source means having a plurality of light beam emitting sections;

a first optical element for converging a plurality of light beams modulated and emitted independently relative to each other from said light source to substantially collimated light beams;

a second optical element for focusing a plurality of said substantially collimated light beams converted as a longitudinal linear image in the main scanning direction on a deflection surface of a defection element;

a third optical element for focusing a plurality of light beams deflected by said deflection element on the image carrier surfaces; and

synchronism detection means for controlling the timing of the start of scanning on said image carrier surfaces using some light beams for synchronism detection among a plurality of light beams deflected by said deflection element, wherein

the synchronism detecting optical element is provided in an optical path between said deflection element and said synchronism detection means and the optical plane of said synchronism detecting optical element is arranged substantially orthogonal relative to said synchronism detection light beams, and

the timing of the start of scanning in the main scanning direction is controlled at or near the center of the scanning width in the main scanning direction on said image carrier surface.

[Claim 22] A color image forming apparatus according to claim 21, wherein said synchronism detecting optical element comprises an anamorphic lens.

[Claim 23] A color image forming apparatus according to claim 21 or 22, wherein said detection optical element is made of a plastic material.

[Claim 24] A color image forming apparatus according to claim 21, wherein said third optical element has a refraction optical element and a diffraction optical element.

[Claim 25] A color image forming apparatus according to claim 24, wherein the refraction optical element and the diffraction optical element of said third optical element are made of a plastic material.

[Claim 26] A color image forming apparatus according to claim 25, wherein said synchronism detecting optical element and the refraction optical

element of said third optical element are integrally formed by using the plastic injection molding.

[Claim 27] A color image forming apparatus according to claim 21, wherein said synchronism detecting optical element and said second optical element are integrally formed by using the plastic injection molding.

[Claim 28] A color image forming apparatus according to any one of claims 21 to 27, wherein said synchronism detection means controls the timing of the start of scanning in the main scanning direction for a plurality of light beams emitted from a plurality of said light beam emitting sections respectively.

[Claim 29] A multibeam scanning optical apparatus comprising:

a light source having a plurality of light beam emitting sections;

a light deflector for deflecting a plurality of light beams emitted respectively from a plurality of said light beam emitting sections of said light source;

a scanning optical system for focusing a plurality of said light beams deflected by said light deflector on a surface to be scanned; and

a photodetector for controlling the timing of the start of scanning of a plurality of said light beams by detecting a part of at least one of a plurality of said light beams deflected by said light deflector as

detection light beam;

said timing of scanning being so controlled as to make the centers of the scanning areas of said light beams agree with each other on the surface to be scanned when a plurality of said light beams have respective wavelengths that are different from each other.

[Claim 30] A multibeam scanning optical apparatus according to claim 29, comprising a detection optical element for converging said detection light beam and leading it to said photodetector; said detection optical element having its optical plane arranged orthogonally relative to the detection light beam.

[Claim 31] A multibeam scanning optical apparatus according to claim 30, wherein said detection optical element comprises an anamorphic lens.

[Claim 32] A multibeam scanning optical apparatus according to claim 30 or 32, wherein said detection optical element is made of a plastic material.

[Claim 33] A multibeam scanning optical apparatus according to claim 29, wherein said scanning optical system comprises a refraction optical element and a diffraction optical element.

[Claim 34] A multibeam scanning optical apparatus according to claim 33, wherein said refraction optical element and said diffraction optical element are made of a plastic material.

[Claim 35] A multibeam scanning optical apparatus according to claim 34, wherein said detection optical element and said refraction optical element are integrally formed by using a plastic material.

[Claim 36] A multibeam scanning optical apparatus according to any one of claims 29 to 35, comprising an incident optical system for leading a plurality of light beams emitted from said light source to said optical deflector.

[Claim 37] A multibeam scanning optical apparatus according to claim 36, wherein said incident optical system comprises a first lens for collimating each of a plurality of said light beams emitted from said light source and a second lens for focusing each of a plurality of said collimated light beams on the deflection plane of the optical deflector as a linear image extending in the main-scanning direction.

[Claim 38] A multibeam scanning optical apparatus according to claim 37, wherein said detection optical element and said second lens are integrally formed by using a plastic material.

[Claim 39] A multibeam scanning optical apparatus according to any one of claims 29 to 38, wherein said photodetector detects part of each of a plurality of light beams deflected by said optical deflector and controls the timing of the start of scanning of each of a plurality of said light beams.

[Claim 40] A multibeam scanning optical apparatus comprising:

a light source having a plurality of light beam emitting sections;

a light deflector for deflecting a plurality of light beams emitted respectively from a plurality of said light beam emitting sections of said light source;

a scanning optical system for focusing a plurality of said light beams deflected by said light deflector on a surface to be scanned;

a photodetector for controlling the timing of the start of scanning of a plurality of said light beams by detecting a part of at least one of a plurality of said light beams deflected by said light deflector as detection light beam; and

a detection optical element for converging said detection light beam and leading it to said photodetector;

said detection optical element having its optical plane arranged orthogonally relative to said detection light beam.

[Claim 41] A multibeam scanning optical apparatus according to claim 40, wherein said detection optical element comprises an anamorphic lens.

[Claim 42] A multibeam scanning optical apparatus according to claim 40 or 41, wherein said detection optical element is made of a plastic material.

[Claim 43] A multibeam scanning optical apparatus according to claim 40, wherein said scanning optical system comprises a refraction optical element and a diffraction optical element.

[Claim 44] A multibeam scanning optical apparatus according to claim 43, wherein said refraction optical element and said diffraction optical element are made of a plastic material.

[Claim 45] A multibeam scanning optical apparatus according to claim 44, wherein said detection optical element and said refraction optical element are integrally formed by using a plastic material.

[Claim 46] A multibeam scanning optical apparatus according to any one of claims 40 to 45, comprising an incident optical system for leading a plurality of light beams emitted from said light source to said optical deflector.

[Claim 47] A color image forming apparatus comprising:

a plurality of scanning optical apparatus; and

a plurality of image carriers arranged respectively on the surfaces to be scanned of said scanning optical apparatus for forming images with respective different colors,

each having a light source, a light deflector for deflecting a light beam emitted from said source, a scanning optical system for focusing the light beam

deflected by said light deflector on a surface to be scanned and a photodetector for controlling the timing of the start of scanning of said light beam by detecting a part of said light beam deflected by said light deflector as detection light beam, said photodetector and the center of the scanning width in the main-scanning direction on the surface to be scanned being held optically equivalent.

[Claim 48] A color image forming apparatus according to claim 47, wherein each of said scanning optical apparatus comprises:

a detection optical element for converging said detection light beam and leading it to said photodetector;

said detection optical element having its optical plane arranged orthogonally relative to the detection light beam.

[Claim 49] A color image forming apparatus according to claim 48, wherein said detection optical element of each of said scanning optical apparatus comprises an anamorphic lens.

[Claim 50] A color image forming apparatus according to claim 48 or 49, wherein said detection optical element of each of said scanning optical apparatus is made of a plastic material.

[Claim 51] A color image forming apparatus according to claim 47, wherein said scanning optical

system of each of said scanning optical apparatus comprises a refraction optical element and a diffraction optical element.

[Claim 52] A color image forming apparatus according to claim 51, wherein said refraction optical element and said diffraction optical element of each of said scanning optical apparatus are made of a plastic material.

[Claim 53] A color image forming apparatus according to claim 52, wherein said detection optical element and said refraction optical element of each of said scanning optical apparatus are integrally formed by using a plastic material.

[Claim 54] A color image forming apparatus according to any one of claims 47 to 53, wherein each of said scanning optical apparatus comprises an incident optical system for leading the light beam emitted from said light source to said optical deflector.

[Claim 55] A color image forming apparatus according to claim 54, wherein said incident optical system of each of said scanning optical apparatus comprises a first lens for collimating the light beam emitted from said light source and a second lens for focusing the collimated light beam on the deflection plane of the optical deflector as a linear image extending in the main-scanning direction.

[Claim 56] A color image forming apparatus according to claim 55, wherein said detection optical element and said second lens of each of said scanning optical apparatus are integrally formed by using a plastic material.

[Claim 57] A color image forming apparatus according to any one of claims 47 to 56, wherein said light source of each of said scanning optical apparatus comprises a plurality of light emitting sections for emitting a plurality of light beams modulated independently relative to each other.

[Claim 58] A color image forming apparatus comprising:

a plurality of scanning optical apparatus; and

a plurality of image carriers arranged respectively on the surfaces to be scanned of said scanning optical apparatus for forming images with respective different colors,

each having a light source, a light deflector for deflecting a light beam emitted from said source, a scanning optical system for focusing the light beam deflected by said light deflector on a surface to be scanned, a photodetector for controlling the timing of the start of scanning of said light beam by detecting a part of said light beam deflected by said light deflector as detection light beam and a detection optical element for converging said detection light

beam and leading it to said photodetector, said detecting optical element having its optical plane arranged orthogonally relative to said detection light beam.

[Claim 59] A color image forming apparatus according to claim 58, wherein said detection optical element of each of said scanning optical apparatus comprises an anamorphic lens.

[Claim 60] A color image forming apparatus according to claim 58 or 59, wherein said detection optical element of each of said scanning optical apparatus is made of a plastic material.

[Claim 61] A color image forming apparatus according to claim 58, wherein said scanning optical system of each of said scanning optical apparatus comprises a refraction optical element and a diffraction optical element.

[Claim 62] A color image forming apparatus according to claim 61, wherein said refraction optical element and said diffraction optical element of each of said scanning optical apparatus are made of a plastic material.

[Claim 63] A color image forming apparatus according to claim 62, wherein said detection optical element and said refraction optical element of each of said scanning optical apparatus are integrally formed by using a plastic material.

[Claim 64] A color image forming apparatus according to any one of claims 58 to 63, wherein each of said scanning optical apparatus comprises an incident optical system for leading the light beam emitted from said light source to said optical deflector.

[Claim 65] A color image forming apparatus according to claim 64, wherein said incident optical system of each of said scanning optical apparatus comprises a first lens for collimating the light beam emitted from said light source and a second lens for focusing the collimated light beam on the deflection plane of the optical deflector as a linear image extending in the main-scanning direction.

[Claim 66] A color image forming apparatus according to claim 65, wherein said detection optical element and said second lens of each of said scanning optical apparatus are integrally formed by using a plastic material.

[Claim 67] A color image forming apparatus according to any one of claims 58 to 66, wherein said light source of each of said scanning optical apparatus comprises a plurality of light emitting sections for emitting a plurality of light beams modulated independently relative to each other.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

This invention relates to a multibeam scanning optical apparatus and also to a color image-forming apparatus. A multibeam scanning optical apparatus is an apparatus adapted to optically scan the surface of an object by means of a plurality of light beams that are emitted from one or more than one light sources, deflected by an optical deflector and transmitted by way of a scanning optical system having an fθ characteristic. A color image-forming apparatus is an apparatus adapted to record image information obtained by scanning the surface of an image carrier by means of deflected light beams. Such apparatus find applications in the field of laser beam printers (LBPs) and digital copying machines having a feature of carrying out a color electrophotography process.

[0002]

[Prior Art]

In conventional scanning optical apparatus to be used for image-forming apparatus such as laser beam printers and digital copying machines, the light beam emitted from a light source and optically modulated according to the image signal applied to it is periodically deflected by a light deflector typically comprising a rotary polygon mirror and then focused on the surface of a photosensitive recording medium (photosensitive drum) to produce a spot of light there

by means of a focusing optical system having an fθ characteristic, which optical system is then used to scan the surface of the recording medium and record the image on the recording medium.

[0003]

Fig. 6 of the accompanying drawings schematically illustrates a principal portion of a known scanning optical apparatus.

[0004]

Referring to Fig. 6, a divergent light beam emitted from light source 81 is substantially collimated by a collimator lens 82 and restricted for quantity by a diaphragm 83 before it enters a cylindrical lens 84 that is made to have a predetermined refractive power only in the sub-scanning direction. The substantially collimated light beam entering the cylindrical lens 84 is then made to exit the leans as a beam substantially collimated in the main-scanning plane, while it is converged in the sub-scanning plane to produce a linear image on the deflection plane (reflection plane) 85a1 of a light deflector 85 comprising a rotary polygon mirror.

[0005]

Then, the light beam deflected and reflected by the deflection plane 85a1 of the light deflector 85 is led to the surface 88 of a photosensitive drum to be scanned by way of a scanning optical element having an

fθ characteristic (fθ lens) 86 so that the surface 88 of the photosensitive drum is optically scanned in the direction indicated by arrow 88a (main-scanning direction) to record the scanned image as the light deflector 85 is driven to rotate in the sense of arrow 85a.

[0006]

In order to accurately control the starting point of the operation of drawing the image for the scanning optical apparatus, the light beam deflected by the light deflector 85 is partly taken out and entered to beam detector (BD) sensor 92 by way of the scanning optical element 86, a beam detector (BD) mirror 95 and a slit 91 immediately prior to the start of writing the image signal. Then, the output signal of the beam detector (BD) sensor 92 is used to regulate the timing and the spot at which the operation of drawing the image on the surface of the photosensitive drum is started.

[0007]

[Problem to be Solved by the Invention]

In recent years, as a result of technological development in the field of image forming apparatus involving the use of an electrophotography process particularly in terms of high speed and high resolution, there is an ever-increasing demand for multibeam scanning optical apparatus comprising a multibeam laser

device having a plurality of light emitting sections and scanning optical apparatus of the type employing a plurality of scanning optical apparatus as so many units in order to realize high speed color image formation as shown in Fig. 7 that illustrates a tandem type color image forming apparatus where a plurality of scanning optical apparatus are operated simultaneously for different colors in order to record image information on respective photosensitive drums as well as hybrid type color image forming apparatus realized by combining apparatus of the above identified types.

[0008]

In Fig. 7, reference numerals 111, 112, 113 and 114 denote respective scanning optical apparatus and reference numerals 121, 122, 123 and 124 denote respective photosensitive drums operating as so many image carriers, whereas reference numerals 131, 132, 133 and 134 denote respective developing units and reference numeral 141 denotes a conveyor belt.

[0009]

Since the manufacturing cost of such scanning optical apparatus is vital, the scanning optical element (fθ lens) is typically prepared by plastic molding without the process of compensating, if any, the chromatic aberration of magnification.

[0010]

However, in the case of a multibeam scanning

optical apparatus adapted to form a final image by means of light beams of a multibeam laser having a plurality of light emitting sections, a plurality of the light beams can show discrepancies in terms of magnification to consequently degrade the quality of the produced image due to various factors including those listed below:

(1) variances of the initial wavelengths of a plurality of light beams emitted from the multibeam laser;

(2) variances of the wavelength of a plurality of the light beams caused by mode hopping of the multibeam laser that is attributable to environmental changes; and

(3) fluctuations in the refractive index of the plastic lens also attributable to environmental changes.

In Fig. 6, there are also shown the image region of the known scanning optical apparatus and the displacements of the focusing positions of the light beams as detected at the start of drawing the image when the wavelength of the light source of laser B (as observed by the laser beam emitted from the light source) is modified relative to the wavelength of the light source of the laser A. Note that, while only the focusing points of laser A and laser B are indicated by A and B respectively in Fig. 6, there are actually more focusing points that are not illustrated in Fig. 6.

[0011]

In an actual image, the displacements of focusing positions on the surface being scanned due to variations of magnification (wavelength) do not give rise to any jittering along the left edge of the image but they do along the right edge of the image as shown in Fig. 8 to consequently degrade the recorded image. This is because the timing and the spot at which the operation of drawing the image on the surface of the photosensitive drum is started are regulated (synchronized) at the side of starting the scanning operation as pointed out above.

[0012]

More specifically, referring to Fig. 6, the detection light beam to be detected by the BD sensor 92 of the known scanning optical apparatus strikes aslant the fθ lens 86 shared with the light beams for scanning the surface to be scanned and, if the wavelength of the laser beam emitted from the laser A differs from that of the light beam emitted from the laser B, they produce a relative deviation of the focusing positions equal to that of the starting points of scanning the surface to be scanned. Thus, the starting points of scanning of the light beams can be made to agree with each other by detecting a part of each of the light beams and so controlling the scanning timing of the beam as to correct the relative deviation of the focusing positions due to the difference of the

wavelengths on the basis of the signals obtained by detecting the laser beams. However, it will be appreciated that, as a result, a remarkable jittering phenomenon can appear at the terminating points of scanning.

[0013]

A similar problem arises in the scanning optical apparatus of tandem type color image forming apparatus. More specifically, when magnification discrepancies arises among a number of scanning optical apparatus, a relative deviation of registration occurs over the range from the center toward the right edge of the image as shown in Fig. 9 among different colors to consequently degrade the produced image. While Fig. 9 shows a relative deviation of registration between B (black) and C (cyan), a similar deviation can occur among any different colors.

[0014]

In view of the above identified circumstances, it is therefore the first object of the present invention to provide a multibeam scanning optical apparatus that can effectively reduce jittering that can arise due to variations (deviations) of magnification among a plurality of light beams attributable to the difference of initial wavelength (wavelength deviation) among a plurality of the light beams emitted from so many light emitting sections and environmental changes even when a

molded plastic lens is used without being subjected to a process of correcting the chromatic aberration of magnification.

[0015]

The second object of the present invention is to provide a color image forming apparatus having a simple configuration and free from the above pointed out problem of tandem type color image forming apparatus that a relative deviation of registration arises among different colors (color deviation) due to the difference of initial wavelength among a plurality of the light beams emitted from so many scanning optical apparatus light emitting sections and environmental changes.

[0016]

[Means for solving the Problem]

A multibeam scanning optical apparatus according to claim 1 is

a multibeam scanning optical apparatus which leads a plurality of light beams modulated and emitted independently relative to each other from a light source having a plurality of light beam emitting sections and scans a surface to be scanned by a plurality of the light beams, wherein

the timing of the start of scanning in the main scanning direction is controlled at or near the center of the scanning width in the main scanning direction on

the surface to be scanned.

[0017]

The invention according to claim 2 is the invention according to claim 1, wherein the timing of the start of scanning in the main scanning direction is controlled for a plurality of light beams emitted from a plurality of the light beam emitting sections.

[0018]

A multibeam scanning optical apparatus according to claim 3 is

a multibeam scanning optical apparatus which leads a plurality of light beams modulated and emitted independently relative to each other from a light source having a plurality of light beam emitting sections and scans a surface to be scanned by a plurality of the light beams, comprising:

a first optical element for converging a plurality of light beams emitted from the light source to substantially collimated light beams;

a second optical element for focusing a plurality of the substantially collimated light beams converted as a longitudinal linear image in the main scanning direction on a deflection surface of a defection element;

a third optical element for focusing a plurality of light beams deflected by the deflection element on the surface to be scanned; and

synchronism detection means for controlling the timing of the start of scanning on the surface to be scanned using some light beams for synchronism detection among a plurality of light beams deflected by the deflection element, wherein

the synchronism detecting optical element is provided in an optical path between the deflection element and the synchronism detection means and the optical plane of the synchronism detecting optical element is arranged substantially orthogonal relative to the synchronism detection light beams, and

the timing of the start of scanning in the main scanning direction is controlled at or near the center of the scanning width in the main scanning direction on the surface to be scanned.

[0019]

The invention according to claim 4 is the invention according to claim 3, wherein the synchronism detecting optical element comprises an anamorphic lens.

[0020]

The invention according to claim 5 is the invention according to claim 3 or 4, wherein the synchronism detecting optical element is made of a plastic material.

[0021]

The invention according to claim 6 is the invention according to claim 3, wherein the third

optical element has a refraction optical element and a diffraction optical element.

[0022]

The invention according to claim 7 is the invention according to claim 6, wherein the refraction optical element and the diffraction optical element of the third optical element are made of a plastic material.

[0023]

The invention according to claim 8 is the invention according to claim 7, wherein the synchronism detecting optical element and the refraction optical element of the third optical element are integrally formed by using the plastic injection molding.

[0024]

The invention according to claim 9 is the invention according to claim 3, wherein the synchronism detecting optical element and the second optical element are integrally formed by using the plastic injection molding.

[0025]

The invention according to claim 10 is the invention according to any one of claims 3 to 9, wherein the synchronism detection means controls the timing of the start of scanning in the main scanning direction for a plurality of light beams emitted from a plurality of the light beam emitting sections

respectively.

[0026]

A color image forming apparatus according to claim 11 is a color image forming apparatus which has a plurality of pairs between a scanning optical apparatus and an image carrier corresponding thereto, leads the light beams emitted from the scanning optical apparatuses to the corresponding image carrier surfaces, scans the image carrier surfaces using the light beams, forms images with different light colors on the image carrier surfaces, and forms a color image based on the images formed on a plurality of the image carrier surfaces, wherein

a plurality of the scanning optical apparatuses control the timing of the start of scanning in the main scanning direction at or near the center of the scanning width in the main scanning direction on the image carrier surface.

[0027]

A color image forming apparatus according to claim 12 is a color image forming apparatus which has a plurality of pairs between a scanning optical apparatus and an image carrier corresponding thereto, leads the light beams emitted from the scanning optical apparatuses to the corresponding image carrier surfaces, scans the image carrier surfaces using the light beams, forms images with different light colors on the image

carrier surfaces, and forms a color image based on the images formed on a plurality of the image carrier surfaces,

and each of a plurality of the scanning optical apparatuses comprises:

light source means comprising semiconductor laser;

a first optical element for converging a plurality of light beams emitted from the light source to substantially collimated light beams;

a second optical element for focusing a plurality of the substantially collimated light beams converted as a longitudinal linear image in the main scanning direction on a deflection surface of a defection element;

a third optical element for focusing a plurality of light beams deflected by the deflection element on the image carrier surfaces; and

synchronism detection means for controlling the timing of the start of scanning on the image carrier surfaces using some light beams for synchronism detection among a plurality of light beams deflected by the deflection element, wherein

the synchronism detecting optical element is provided in an optical path between the deflection element and the synchronism detection means and the optical plane of the synchronism detecting optical element is arranged substantially orthogonal relative

to the synchronism detection light beams, and

the timing of scanning in the main scanning direction is controlled at or near the center of the scanning width in the main scanning direction on the image carrier surface.

[0028]

The invention according to claim 13 is the invention according to claim 12, wherein the synchronism detecting optical element comprises an anamorphic lens.

[0029]

The invention according to claim 14 is the invention according to claim 12 or 13, wherein the synchronism detecting optical element is made of a plastic material.

[0030]

The invention according to claim 15 is the invention according to claim 12, wherein the third optical element has a refraction optical element and a diffraction optical element.

[0031]

The invention according to claim 16 is the invention according to claim 15, wherein the refraction optical element and the diffraction optical element of the third optical element are made of a plastic material.

[0032]

The invention according to claim 17 is the invention according to claim 16, wherein the synchronism detecting optical element and the refraction optical element of the third optical element are integrally formed by using the plastic injection molding.

[0033]

The invention according to claim 18 is the invention according to claim 12, wherein the synchronism detecting optical element and the second optical element are integrally formed by using the plastic injection molding.

[0034]

A color image forming apparatus according to claim 19 is a color image forming apparatus which has a plurality of pairs between a scanning optical apparatus, including light source means having a plurality of light beam emitting sections, and an image carrier corresponding thereto, leads a plurality of light beams modulated and emitted independently relative to each other from the scanning optical apparatuses to the corresponding image carrier surfaces, scans the image carrier surfaces using a plurality of the light beams, forms images with different light colors on the image carrier surfaces, and forms a color image based on the images formed on a plurality of the image carrier surfaces, wherein

a plurality of the scanning optical apparatuses control the timing of the start of scanning in the main scanning direction at or near the center of the scanning width in the main scanning direction on the image carrier surface.

[0035]

The invention according to claim 20 is the invention according to claim 19, wherein each of the timing of the start of scanning in the main scanning direction for a plurality of light beams emitted from a plurality of the light beam emitting sections respectively is controlled.

[0036]

A color image forming apparatus according to claim 21 is a color image forming apparatus which has a plurality of pairs between a scanning optical apparatus and an image carrier corresponding thereto, leads the light beams emitted from the scanning optical apparatuses to the corresponding image carrier surfaces, scans the image carrier surfaces using the light beams, forms images with different light colors on the image carrier surfaces, and forms a color image based on the images formed on a plurality of the image carrier surfaces,

and each of a plurality of the scanning optical apparatuses comprises:

light source means having a plurality of light

beam emitting sections;

a first optical element for converging a plurality of light beams modulated and emitted independently relative to each other from the light source to substantially collimated light beams;

a second optical element for focusing a plurality of the substantially collimated light beams converted as a longitudinal linear image in the main scanning direction on a deflection surface of a defection element;

a third optical element for focusing a plurality of light beams deflected by the deflection element on the image carrier surfaces; and

synchronism detection means for controlling the timing of the start of scanning on the image carrier surfaces using some light beams for synchronism detection among a plurality of light beams deflected by the deflection element, wherein

the synchronism detecting optical element is provided in an optical path between the deflection element and the synchronism detection means and the optical plane of the synchronism detecting optical element is arranged substantially orthogonal relative to the synchronism detection light beams, and

the timing of the start of scanning in the main scanning direction is controlled at or near the center of the scanning width in the main scanning direction on

the image carrier surface.

[0037]

The invention according to claim 22 is the invention according to claim 21, wherein the synchronism detecting optical element comprises an anamorphic lens.

[0038]

The invention according to claim 23 is the invention according to claim 21 or 22, wherein the detection optical element is made of a plastic material.

[0039]

The invention according to claim 24 is the invention according to claim 21, wherein the third optical element has a refraction optical element and a diffraction optical element.

[0040]

The invention according to claim 25 is the invention according to claim 24, wherein the refraction optical element and the diffraction optical element of the third optical element are made of a plastic material.

[0041]

The invention according to claim 26 is the invention according to claim 25, wherein the synchronism detecting optical element and the refraction optical element of the third optical element are integrally formed by using the plastic injection

molding.

[0042]

The invention according to claim 27 is the invention according to claim 21, wherein the synchronism detecting optical element and the second optical element are integrally formed by using the plastic injection molding.

[0043]

The invention according to claim 28 is the invention according to any one of claims 21 to 27, wherein the synchronism detection means controls the timing of the start of scanning in the main scanning direction for a plurality of light beams emitted from a plurality of the light beam emitting sections respectively.

[0044]

A multibeam scanning optical apparatus according to claim 29 is a multibeam scanning optical apparatus comprising:

a light source having a plurality of light beam emitting sections;

a light deflector for deflecting a plurality of light beams emitted respectively from a plurality of the light beam emitting sections of the light source;

a scanning optical system for focusing a plurality of the light beams deflected by the light deflector on a surface to be scanned; and

a photodetector for controlling the timing of the start of scanning of a plurality of the light beams by detecting a part of at least one of a plurality of the light beams deflected by the light deflector as detection light beam;

the timing of scanning being so controlled as to make the centers of the scanning areas of the light beams agree with each other on the surface to be scanned when a plurality of the light beams have respective wavelengths that are different from each other.

[0045]

The invention according to claim 30 is the invention according to claim 29, comprising a detection optical element for converging the detection light beam and leading it to the photodetector; the detection optical element having its optical plane arranged orthogonally relative to the detection light beam.

[0046]

The invention according to claim 31 is the invention according to claim 30, wherein the detection optical element comprises an anamorphic lens.

[0047]

The invention according to claim 32 is the invention according to claim 30 or 32, wherein the detection optical element is made of a plastic material.

[0048]

The invention according to claim 33 is the invention according to claim 29, wherein the scanning optical system comprises a refraction optical element and a diffraction optical element.

[0049]

The invention according to claim 34 is the invention according to claim 33, wherein the refraction optical element and the diffraction optical element are made of a plastic material.

[0050]

The invention according to claim 35 is the invention according to claim 34, wherein the detection optical element and the refraction optical element are integrally formed by using a plastic material.

[0051]

The invention according to claim 36 is the invention according to any one of claims 29 to 35, comprising an incident optical system for leading a plurality of light beams emitted from the light source to the optical deflector.

[0052]

The invention according to claim 37 is the invention according to claim 36, wherein the incident optical system comprises a first lens for collimating each of a plurality of the light beams emitted from the light source and a second lens for focusing each of a plurality of the collimated light beams on the

deflection plane of the optical deflector as a linear image extending in the main-scanning direction.

[0053]

The invention according to claim 38 is the invention according to claim 37, wherein the detection optical element and the second lens are integrally formed by using a plastic material.

[0054]

The invention according to claim 39 is the invention according to any one of claims 29 to 38, wherein the photodetector detects part of each of a plurality of light beams deflected by the optical deflector and controls the timing of the start of scanning of each of a plurality of the light beams.

[0055]

A multibeam scanning optical apparatus according to claim 40 is a multibeam scanning optical apparatus comprising:

a light source having a plurality of light beam emitting sections;

a light deflector for deflecting a plurality of light beams emitted respectively from a plurality of the light beam emitting sections of the light source;

a scanning optical system for focusing a plurality of the light beams deflected by the light deflector on a surface to be scanned;

a photodetector for controlling the timing of the

start of scanning of a plurality of the light beams by detecting a part of at least one of a plurality of the light beams deflected by the light deflector as detection light beam; and

a detection optical element for converging the detection light beam and leading it to the photodetector;

the detection optical element having its optical plane arranged orthogonally relative to the detection light beam.

[0056]

The invention according to claim 41 is the invention according to claim 40, wherein the detection optical element comprises an anamorphic lens.

[0057]

The invention according to claim 42 is the invention according to claim 40 or 41, wherein the detection optical element is made of a plastic material.

[0058]

The invention according to claim 43 is the invention according to claim 40, wherein the scanning optical system comprises a refraction optical element and a diffraction optical element.

[0059]

The invention according to claim 44 is the invention according to claim 43, wherein the refraction optical element and the diffraction optical element are

made of a plastic material.

[0060]

The invention according to claim 45 is the invention according to claim 44, wherein the detection optical element and the refraction optical element are integrally formed by using a plastic material.

[0061]

The invention according to claim 46 is the invention according to any one of claims 40 to 45, comprising an incident optical system for leading a plurality of light beams emitted from the light source to the optical deflector.

[0062]

A color image forming apparatus according to claim 47 is a color image forming apparatus comprising:

a plurality of scanning optical apparatus; and

a plurality of image carriers arranged respectively on the surfaces to be scanned of the scanning optical apparatus for forming images with respective different colors,

each having a light source, a light deflector for deflecting a light beam emitted from the source, a scanning optical system for focusing the light beam deflected by the light deflector on a surface to be scanned and a photodetector for controlling the timing of the start of scanning of the light beam by detecting a part of the light beam deflected by the light

deflector as detection light beam, the photodetector and the center of the scanning width in the main-scanning direction on the surface to be scanned being held optically equivalent.

[0063]

The invention according to claim 48 is the invention according to claim 47, wherein each of the scanning optical apparatus comprises:

a detection optical element for converging the detection light beam and leading it to the photodetector;

the detection optical element having its optical plane arranged orthogonally relative to the detection light beam.

[0064]

The invention according to claim 49 is the invention according to claim 48, wherein the detection optical element of each of the scanning optical apparatus comprises an anamorphic lens.

[0065]

The invention according to claim 50 is the invention according to claim 48 or 49, wherein the detection optical element of each of the scanning optical apparatus is made of a plastic material.

[0066]

The invention according to claim 51 is the invention according to claim 47, wherein the scanning

optical system of each of the scanning optical apparatus comprises a refraction optical element and a diffraction optical element.

[0067]

The invention according to claim 52 is the invention according to claim 51, wherein the refraction optical element and the diffraction optical element of each of the scanning optical apparatus are made of a plastic material.

[0068]

The invention according to claim 53 is the invention according to claim 52, wherein the detection optical element and the refraction optical element of each of the scanning optical apparatus are integrally formed by using a plastic material.

[0069]

The invention according to claim 54 is the invention according to any one of claims 47 to 53, wherein each of the scanning optical apparatus comprises an incident optical system for leading the light beam emitted from the light source to the optical deflector.

[0070]

The invention according to claim 55 is the invention according to claim 54, wherein the incident optical system of each of the scanning optical apparatus comprises a first lens for collimating the

light beam emitted from the light source and a second lens for focusing the collimated light beam on the deflection plane of the optical deflector as a linear image extending in the main-scanning direction.

[0071]

The invention according to claim 56 is the invention according to claim 55, wherein the detection optical element and the second lens of each of the scanning optical apparatus are integrally formed by using a plastic material.

[0072]

The invention according to claim 57 is the invention according to any one of claims 47 to 56, wherein the light source of each of the scanning optical apparatus comprises a plurality of light emitting sections for emitting a plurality of light beams modulated independently relative to each other.

[0073]

A color image forming apparatus according to claim 58 is a color image forming apparatus comprising:

a plurality of scanning optical apparatus; and

a plurality of image carriers arranged respectively on the surfaces to be scanned of the scanning optical apparatus for forming images with respective different colors,

each having a light source, a light deflector for deflecting a light beam emitted from the source, a

scanning optical system for focusing the light beam deflected by the light deflector on a surface to be scanned, a photodetector for controlling the timing of the start of scanning of the light beam by detecting a part of the light beam deflected by the light deflector as detection light beam and a detection optical element for converging the detection light beam and leading it to the photodetector, the detecting optical element having its optical plane arranged orthogonally relative to the detection light beam.

[0074]

The invention according to claim 59 is the invention according to claim 58, wherein the detection optical element of each of the scanning optical apparatus comprises an anamorphic lens.

[0075]

The invention according to claim 60 is the invention according to claim 58 or 59, wherein the detection optical element of each of the scanning optical apparatus is made of a plastic material.

[0076]

The invention according to claim 61 is the invention according to claim 58, wherein the scanning optical system of each of the scanning optical apparatus comprises a refraction optical element and a diffraction optical element.

[0077]

The invention according to claim 62 is the invention according to claim 61, wherein the refraction optical element and the diffraction optical element of each of the scanning optical apparatus are made of a plastic material.

[0078]

The invention according to claim 63 is the invention according to claim 62, wherein the detection optical element and the refraction optical element of each of the scanning optical apparatus are integrally formed by using a plastic material.

[0079]

The invention according to claim 64 is the invention according to any one of claims 58 to 63, wherein each of the scanning optical apparatus comprises an incident optical system for leading the light beam emitted from the light source to the optical deflector.

[0080]

The invention according to claim 65 is the invention according to claim 64, wherein the incident optical system of each of the scanning optical apparatus comprises a first lens for collimating the light beam emitted from the light source and a second lens for focusing the collimated light beam on the deflection plane of the optical deflector as a linear image extending in the main-scanning direction.

[0081]

The invention according to claim 66 is the invention according to claim 65, wherein the detection optical element and the second lens of each of the scanning optical apparatus are integrally formed by using a plastic material.

[0082]

The invention according to claim 67 is the invention according to any one of claims 58 to 66, wherein the light source of each of the scanning optical apparatus comprises a plurality of light emitting sections for emitting a plurality of light beams modulated independently relative to each other.

[0083]

When a plurality of the light beams show respective wavelengths that are different from each other in a multibeam optical apparatus according to the invention, the timing of the start of scanning is so controlled as to make the centers of the scanning areas of the light beams agree with each other on the surface to be scanned simply by controlling the timing of scanning in the main-scanning direction at or near the center of the scanning width in the main-scanning direction on the surface to be scanned by means of the photodetector (BD) sensor. This means that the photodetector and the center of the scanning width in the main-scanning direction on the surface to be

scanned are held optically equivalent.

[0084]

Similarly, in each of the scanning optical apparatus of a color image forming apparatus according to the invention, the timing of the start of scanning is so controlled as to make the centers of the scanning areas of the light beams agree with each other on the surface to be scanned simply by controlling the timing of scanning in the main-scanning direction at or near the center of the scanning width in the main-scanning direction on the surface to be scanned by means of the photodetector (BD) sensor.

[0085]

The photodetector and the center of the scanning width in the main-scanning direction on the surface to be scanned can be held optically equivalent by so arranging the detecting optical element for focusing the detection light beam and leading it to the photodetector (BD) sensor as to have its optical plane arranged orthogonally relative to the detection light beam. This is because the main light beam of the flux of light striking the center of the scanning width in the main-scanning direction generally agrees with the optical axis of the scanning optical system (fθ lens) and hence this light beam and the light beam entering the photodetector (BD) sensor are made to optically equivalent.

[0086]

For the purpose of the invention, the expression that "the detecting optical element having its optical plane arranged orthogonally relative to the detection light beam" means that the main light beam of the flux of light as detected by the photodetector (BD) sensor substantially agrees with the optical axis of the detecting optical element. The expression "as detected by the photodetector" is used because the light beam entering the photodetector is used for scanning and therefore the main light beam of the flux of light does not always agree with the optical axis of the detecting optical element. In other words, there exists a state where the main light beam of the flux of light being used for scanning can agree with optical axis of the detecting optical element.

[0087]

[Embodiment(s)]

[Embodiment 1]

Fig. 1 is a schematic cross sectional view of a principal portion of the first embodiment of multibeam scanning optical apparatus according to the present invention taken along the main-scanning direction thereof (a main-scanning cross sectional view).

[0088]

In Fig. 1, reference numeral 1 denotes a light source comprising a multi-semiconductor laser

(multibeam laser) having a plurality of light emitting sections (laser A and laser B in this embodiment) for emitting a plurality of light beams that are optically modulated independently relative to each other.

[0089]

Reference numeral 2 denotes a collimator lens operating as first optical element for collimating a plurality of the light beams emitted from the light source 1. Reference numeral 3 denotes a diaphragm 3 for restricting the quantity of light passing therethrough. Reference numeral 4 denotes a cylindrical lens (cylinder lens) operating as second optical element and showing refractive power of a predetermined level only in the sub-scanning direction. It focuses, in the direction of the sub-scanning plane, a plurality of the light beams passing through the diaphragm 3 on the deflection plane (reflection plane) 5a1 of optical deflector 5, which will be described below, as a linear image.

[0090]

Each of the elements such as the collimator lens 2, the cylindrical lens 4 and the like comprises one element of the incident optical system.

[0091]

Reference numeral 5 denotes an optical deflector that may be a rotary polygon mirror driven to rotate at a predetermined rate in the sense indicated by arrow 5a

in Fig. 1 by a drive means (not shown) such as an electric motor.

[0092]

Reference numeral 6 denotes a scanning optical element (scanning optical system) operating as third optical element showing a fθ characteristic and comprising a refraction optical element 61 and a diffraction optical element 62. The refraction optical element 61 consists of a single plastic toric lens whose optical power differs between the main-scanning direction and the sub-scanning direction. The diffraction optical element 62 consists of an oblong plastic diffraction element whose optical power differs between the main-scanning direction and the sub-scanning direction. While the oblong diffraction element 62 of this embodiment is made of plastic and formed by injection molding, it may alternatively be a diffraction grating formed as replica on a glass substrate.

[0093]

In this embodiment, the toric lens 61 is arranged at the side of the polygon mirror 5 relative to the middle point of the axis of rotation of the polygon mirror 5 and the surface to be scanned 8, whereas the diffraction optical element 62 is arranged at the side of the surface to be scanned relative to the middle point. Each of the above listed optical elements has

optical power that differs between the main-scanning direction and the sub-scanning direction and operates to focus the deflected light beam from the polygon mirror 5 on the surface to be scanned and correct the inclination of the deflection plane of the polygon mirror.

[0094]

When the multibeam scanning optical apparatus is applied to an electronic photograph printer, the surface to be scanned 8 refers to the surface of the photosensitive drum of the printer. Therefore, reference numeral 8 refers to the surface of a photosensitive drum hereinafter.

[0095]

Reference numeral 7 denotes a synchronism detecting optical element comprising an anamorphic lens made of plastic and showing optical power that differs between the main-scanning direction and the sub-scanning direction. In this embodiment, the surface (optical surface) of the anamorphic lens 7 is arranged substantially orthogonally relative to a plurality of the light beams from the polygon mirror 5 (synchronism detection light beams) 73 for controlling the timing of the start of scanning the surface of the photosensitive drum 8 in the main-scanning direction (timing of scanning, synchronizing timing) and adapted to focus the synchronism detection light beam 73 near slit 71

both in the main-scanning plane and the sub-scanning plane.

[0096]

The surface of the anamorphic lens 7 is arranged orthogonally relative to the synchronism detection light beams (detection light beams) 73 means that the main light of the light beams detected by the light detector (BD sensor) substantially agrees with the optical axis of the anamorphic lens 7, as described above.

[0097]

Reference numeral 75 denotes a mirror (to be referred to as "BD mirror" hereinafter) for reflecting the synchronism detection light beams 73 to BD sensor 72, which will be described hereinafter, in order to regulate the timing of scanning the surface of the photosensitive drum 8 in the main-scanning direction. Reference numeral 71 denotes a slit arranged at a position equivalent to the surface of the photosensitive drum 8. Reference numeral 74 denotes a beam detector lens (BD lens) operating as focusing lens for making the BD mirror 75 and the BD sensor 72 show a conjugated relationship and correcting the inclination of the BD mirror 75. Reference numeral 72 denotes a synchronism detection means comprising the BD sensor (photosensor).

[0098]

The synchronism detection means 72 of this embodiment is used to control the timing of the start of scanning of each of a plurality of the light beams emitted from a plurality of the light emitting sections in the main-scanning direction at or near the center of the scanning width on the surface of the photosensitive drum 8.

[0099]

In other words, if a plurality of the light beams have respective wavelengths that are different from each other in this embodiment, the timing of starting a scanning operation of each light beam is so controlled that the centers of the scanning areas of a plurality of the light beams agree with each other on the surface to be scanned. This means that it is constructed so that the BD sensor 72 and the center position of the scanning width in the main scanning direction on the surface to be scanned 8 are optically equivalent.

[0100]

The wavelength of a light beam means that, for example, the central wavelength of emission spectrum or central wavelength of emission spectrum distribution.

[0101]

In this embodiment, a pair of divergent light beams (only one of them is shown in Fig. 1) optically modulated and emitted from the multi-semiconductor laser 1 as a function of image information applied to

it are substantially collimated by the collimator lens 2 and restricted by the diaphragm 3 for the quantity of light before entering the cylindrical lens 4. The two substantially collimated light beams entering the cylindrical lens 4 then leave the lens without being modified in the main-scanning plane but converged in the sub-scanning plane to produce respective focused linear images (running along main-scanning direction) on the deflection plane 5a1 of the optical deflector (polygon mirror) 5. The two light beams deflected by the deflection plane 5a1 of the optical deflector 5 are then focused as so many spots of light on the surface of the photosensitive drum 8 by way of the toric lens 61 and the refraction optical element 62 so that they scan the surface of the photosensitive drum 8 at a constant rate in the direction (main-scanning direction) as indicated by arrow 8a as the optical deflector 5 is rotated in the sense of arrow 5a. As a result, an image is recorded on the surface of the photosensitive drum 8, which is a recording medium.

[0102]

At the same time, the two synchronism detection light beams 73 reflected and deflected by the polygon mirror 5 of this embodiment are led to the BD sensor 72 by way of the synchronism detecting optical element 7, the BD mirror 75, the slit 71 and the BD lens 74. Then, the two BD signals (synchronizing signals) for the

main-scanning direction obtained by detecting the output signal of the BD sensor 72 are used to control the timing of scanning (synchronizing timing) in the main-scanning direction at or near the center of the scanning width in the main-scanning direction on the surface of the photosensitive drum 8.

[0103]

As pointed out above, the surfaces of the single anamorphic lens 7 made of a plastic material and formed by injection molding is arranged substantially orthogonally relative to the synchronism detection light beams 73 in this embodiment. As a result, if, for instance, the wavelength of the light source of the laser B is shifted relative to the laser A of the multi-semiconductor laser 1 as shown in Fig. 1, the synchronism detection timing (write synchronizing signal) will not be shifted in the main-scanning direction. Note that only the focused positions of the light beams from the lasers A and B are shown in Fig. 1.

[0104]

On the other hand, because the timing of scanning is controlled in the main-scanning direction at or near the center of the scanning width in the main-scanning direction on the surface of the photosensitive drum 8, if the wavelength of the light source of the laser B is shifted relative to the laser A, the positions (focused positions) of the light beams on the surface of the

photosensitive drum 8 agree with each other only on the optical axis of the scanning optical element 6 and the magnification of the scanning optical element shows variations that are symmetrical relative to the optical axis in any other positions. Variations of the refractive index of the scanning optical element 6 due to environmental changes also show similar results.

[0105]

Thus, in this embodiment, the synchronism detection timing does not shift regardless of variations in the wavelength and those in the refractive index due to environmental changes so that the focusing positions of the image area are made to vary symmetrically relative to the optical axis of the scanning optical element 6 as shown in Fig. 2. As a result, the variations in the magnification can be allocated to the starting side and the terminating side of image drawing to consequently reduce the extent of jittering to about a half of that of known comparable apparatus.

[0106]

Therefore with the embodiment where the timing of the start of scanning is controlled in the main-scanning direction at or near the center of the scanning width in the main-scanning direction on the surface of the photosensitive drum 8 and the surfaces of the single anamorphic lens 7 are arranged

substantially orthogonally relative to the synchronism detection light beams 73, the jittering phenomenon of the multibeam scanning optical apparatus attributable to variations in the wavelength (initial wavelength) and those in the magnification due to environmental changes can be effectively suppressed even an inexpensive plastic lens formed by injection molding and not corrected for chromatic aberration of magnification is used for the scanning optical element.

[0107]

Note that the scanning optical element of this embodiment comprises a refraction optical element and a diffraction optical element, the advantages of the first embodiment can be realized by using a scanning optical element comprising only a refraction optical element.

[0108]

Furthermore, the synchronism detecting optical element comprises the anamorphic lens in this example, but even by comprising a cylindrical lens the present invention can also be applied in the same way as the first embodiment mentioned above.

[0109]

[Embodiment 2]

Fig. 3 is a schematic cross sectional view of a principal portion of the second embodiment of a color image forming apparatus according to the present

invention.

[0110]

Differences of the present embodiment from Embodiment 1 are that this embodiment comprises a tandem type color image forming apparatus, in which the four scanning optical apparatuses are arranged to record image information on the surfaces of the corresponding photosensitive drums, image carriers, in parallel and that the light source means of the scanning optical apparatuses are constructed by a single-beam laser. Otherwise, this embodiment is substantially identical with the first embodiment in terms of configuration and optical effect.

[0111]

In Fig. 3, reference numerals 11, 12, 13 and 14 denote respective scanning optical apparatus and reference numerals 21, 22, 23 and 24 denote respective photosensitive drums operating as so many image carriers, whereas reference numerals 31, 32, 33 and 34 denote respective developing units and reference numeral 41 denotes a conveyor belt.

[0112]

This embodiment of color image forming apparatus comprises a total of four scanning optical apparatus (11, 12, 13, 14) arranged for the four colors of C (cyan), M (magenta), Y (yellow) and B (black) and is adapted to record respective image signals (image

information) on the corresponding photosensitive drums 21, 22, 23 and 24 in parallel and carry out a color image printing operation at high speed.

[0113]

As pointed out above, the color image forming apparatus of this embodiment is adapted to form latent images on the corresponding surfaces of the respective photosensitive drums 21, 22, 23 and 24 by means of respective light beams emitted from the four scanning optical apparatus 11, 12, 13 and 14 according to respective modulation signals. More specifically, latent images of C (cyan), M (magenta), Y (yellow) and B (black) are formed on the corresponding surfaces of the respective photosensitive drums 21, 22, 23 and 24 and then transferred on a recording medium in a multiplexing fashion to produce a single full color image.

[0114]

Thus, a color image can be printed at high speed as if a monochromatic image. However, since the four colors do not share a single scanning optical element in this embodiment, they can show variations in terms of scanning position (registration) to consequently produce a relative deviation of registration among different colors and degrade the produced image.

[0115]

To avoid this problem, in this embodiment of

tandem type color image forming apparatus comprising a plurality of scanning optical apparatus, the timing of scanning of each of the scanning optical apparatus is controlled on the surface of the corresponding photosensitive drum at or near the center of the scanning width in the main-scanning direction in a manner as described above by referring to the first embodiment.

[0116]

In other words, the photodetector (BD) sensor and the center of the scanning width in the main-scanning direction on the surface to be scanned are optically held equivalent. To realize this, the surfaces of the synchronism detecting optical element (anamorphic lens) made of a plastic material and formed by molding as a single piece are arranged substantially orthogonally relative to the synchronism detection light beam in each of the scanning optical apparatus.

[0117]

As a result, as described above by referring to the first embodiment, the timing of synchronism detection is not shifted if the wavelengths of the light sources of the four scanning optical apparatus are varied from each other. Similarly, the timing of synchronism detection is not shifted if the refractive index of any of the synchronism detecting optical elements is shifted due to environmental changes.

[0118]

On the other hand, because the timing of scanning is controlled in the main-scanning direction at or near the center of the scanning width in the main-scanning direction on the surface of each of the photosensitive drums, if the wavelength of the light source of any of the four scanning optical apparatus is shifted relative to the others, the positions (focused positions) of the light beams on the surface of the photosensitive drum agree with each other only on the optical axis of the scanning optical element and the magnification of the scanning optical element shows variations that are symmetrical relative to the optical axis at any other positions. Variations of the refractive index of the scanning optical element due to environmental changes also shows similar results.

[0119]

Thus, in this embodiment, the synchronism detection timing does not shift regardless of variations in the wavelength and those in the refractive index due to environmental changes so that the focusing positions of the image area are made to vary symmetrically relative to the optical axis of the scanning optical element as shown in Fig. 4. As a result, the variations in the magnification can be allocated to the starting side and the terminating side of image drawing to consequently reduce the extent of

relative deviation of registration among different colors to about a half of that of known comparable apparatus. Note that while Fig. 4 shows color deviation between B (black) and C (cyan), similar results are obtained for other colors.

[0120]

Therefore with the embodiment of scanning optical apparatus used for a tandem type color image forming apparatus where the timing of the start of scanning is controlled in the main-scanning direction at or near the center of the scanning width in the main-scanning direction on the surface of the photosensitive drum and the surfaces of the single anamorphic lens are arranged substantially orthogonally relative to the synchronism detection light beams in each of the scanning optical apparatus, the extent of relative deviation of registration among different colors attributable to variations in the wavelength and those in the magnification due to environmental changes can be effectively suppressed even an inexpensive plastic lens formed by injection molding and not corrected for chromatic aberration of magnification is used for the scanning optical element.

[0121]

Note that the scanning optical apparatus of this embodiment of color image forming apparatus may be replaced by the multibeam scanning optical apparatus as

described above by referring to the first embodiment. Then, the obtained color image forming apparatus can be operated for an enhanced degree of high speed operation and high definition.

[0122]

[Embodiment 3]

Fig. 5 is a schematic cross sectional view of a principal portion of the third embodiment of the invention, which is also a multibeam scanning optical apparatus, taken along the main-scanning direction thereof (a main scanning cross sectional view). In Fig. 5, the components same as those of Fig. 1 are denoted respectively by the same reference symbols.

[0123]

This embodiment differs from the first embodiment only in that the synchronism detecting optical element is formed integrally with the refraction optical element of the scanning optical element by injection molding using a plastic material. Otherwise, this embodiment is substantially identical with the first embodiment in terms of configuration and optical effect. Thus, this embodiment operates like the first embodiment.

[0124]

Referring to Fig. 5, reference numeral 17 denotes the integral type plastic optical element formed by injection molding and operating as synchronism

detecting optical element which is an anamorphic lens and also as refraction optical element which is a toric lens. With this arrangement, any spatial interference of the synchronism detecting optical element and the refraction optical element is eliminated to make it possible to detect the scanning position at a position close to the image area and reduce the jittering phenomenon.

[0125]

Note that, while the synchronism detecting optical element and the refraction optical element are integrally formed in this embodiment, the synchronism detecting optical element and the second optical element which is the cylindrical lens may alternatively formed as integral components by injection molding, using plastic as raw material. Still alternatively, the synchronism detecting optical element, the refraction optical element and the cylindrical lens may be integrally formed by injection molding, using plastic as raw material. This embodiment may be applied to a color image forming apparatus as described above by referring to the second embodiment.

[0126]

[Effect of the Invention]

According to the present invention, as mentioned above, it is possible to realize a multibeam scanning optical apparatus that can effectively reduce jittering

that can arise due to variations (deviations) of magnification among a plurality of light beams attributable to the difference of initial wavelength (wavelength deviation) among a plurality of the light beams emitted from so many light emitting sections and environmental changes even when a molded plastic lens is used without being subjected to a process of correcting the chromatic aberration of magnification.

[0127]

According to the present invention, as mentioned above, it is also possible to realize a color image forming apparatus having a simple configuration and free from the above pointed out problem of tandem type color image forming apparatus that a relative deviation of registration arises among different colors (color deviation) due to the difference of initial wavelength among a plurality of the light beams emitted from so many scanning optical apparatus light emitting sections and environmental changes.

[Brief Description of the Drawings]

[Fig. 1] A schematic view of a principal portion of the multibeam scanning optical apparatus according to the first embodiment of the present invention.

[Fig. 2] A schematic illustration, which is an output sample according to the first embodiment of the present invention and shows the status of the jittering, taken along the main-scanning direction thereof.

[Fig. 3] A schematic cross sectional view of a principal portion of the first embodiment of the present invention, which is a color image forming apparatus.

[Fig. 4] A schematic illustration, which is an output sample according to the second embodiment of the present invention and shows the status of the jittering, taken along the main-scanning direction thereof.

[Fig. 5] A schematic view of a principal portion of the multibeam scanning optical apparatus according to the third embodiment of the present invention.

[Fig. 6] A schematic illustration of a principal portion of a known scanning optical apparatus.

[Fig. 7] A schematic illustration of a principal portion of a known multibeam scanning optical apparatus.

[Fig. 8] A schematic illustration showing an output image when a jittering is caused due to deviations of among two light beams in a multibeam scanning optical apparatus.

[Fig. 9] A schematic illustration showing an output image when color deviations are caused due to deviations of magnification among colors in the scanning optical system of a color image forming apparatus.

[Description of Reference Numerals or Symbols]

1 Light source means (multi-semiconductor laser)

2 First optical element (collimator lens)

3 Diaphragm

4 Second optical element (cylindrical lens)

5 Deflection element (polygon mirror)

6 Scanning optical element

7 Synchronism detecting optical element

61 Refraction optical element (toric lens)

62 refraction optical element

8 Surface to be scanned (photosensitive drum)

71 Slit

72 Synchronism detection means

73 Synchronism detection light beams

74 Focusing means

75 BD mirror

17 Integral type optical element

11, 12, 13, 14 Scanning optical apparatus

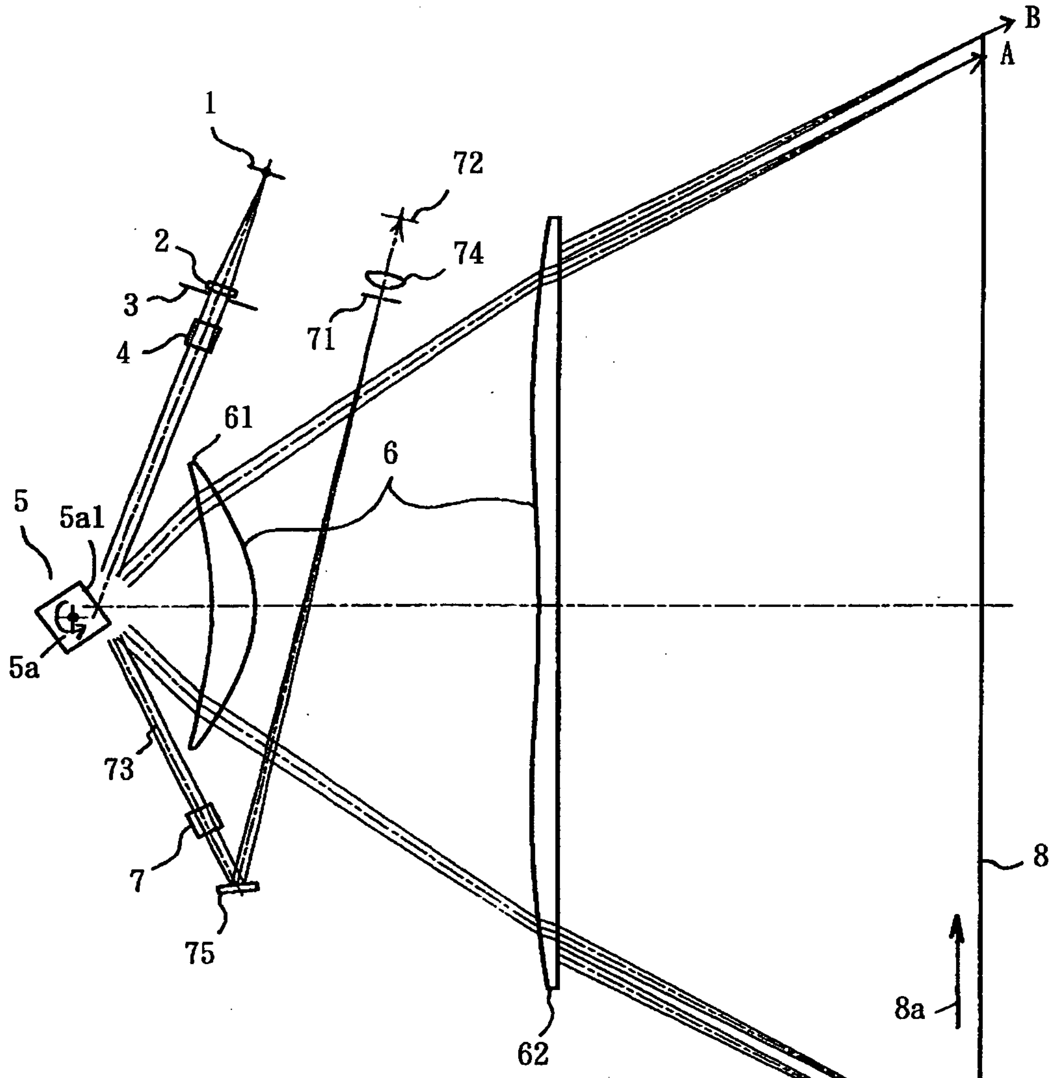
21, 22, 23, 24 Image carrier (photosensitive drum)

31, 32, 33, 34 Developing unit

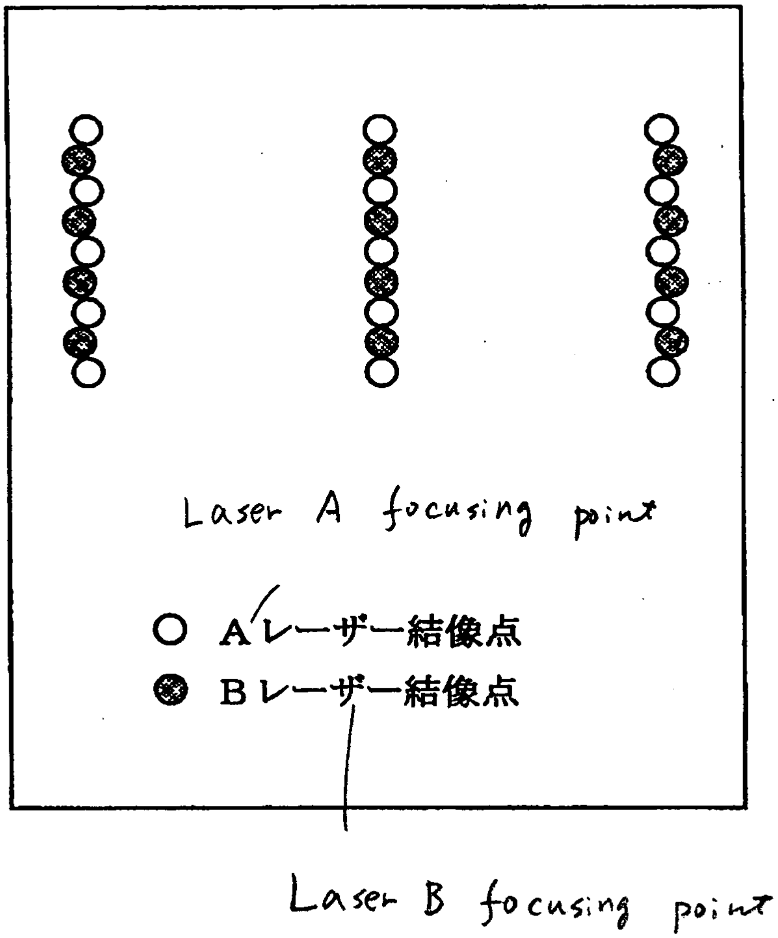
41 Conveyor belt

【書類名】　　　図面　〔Name of the Document〕 Drawings

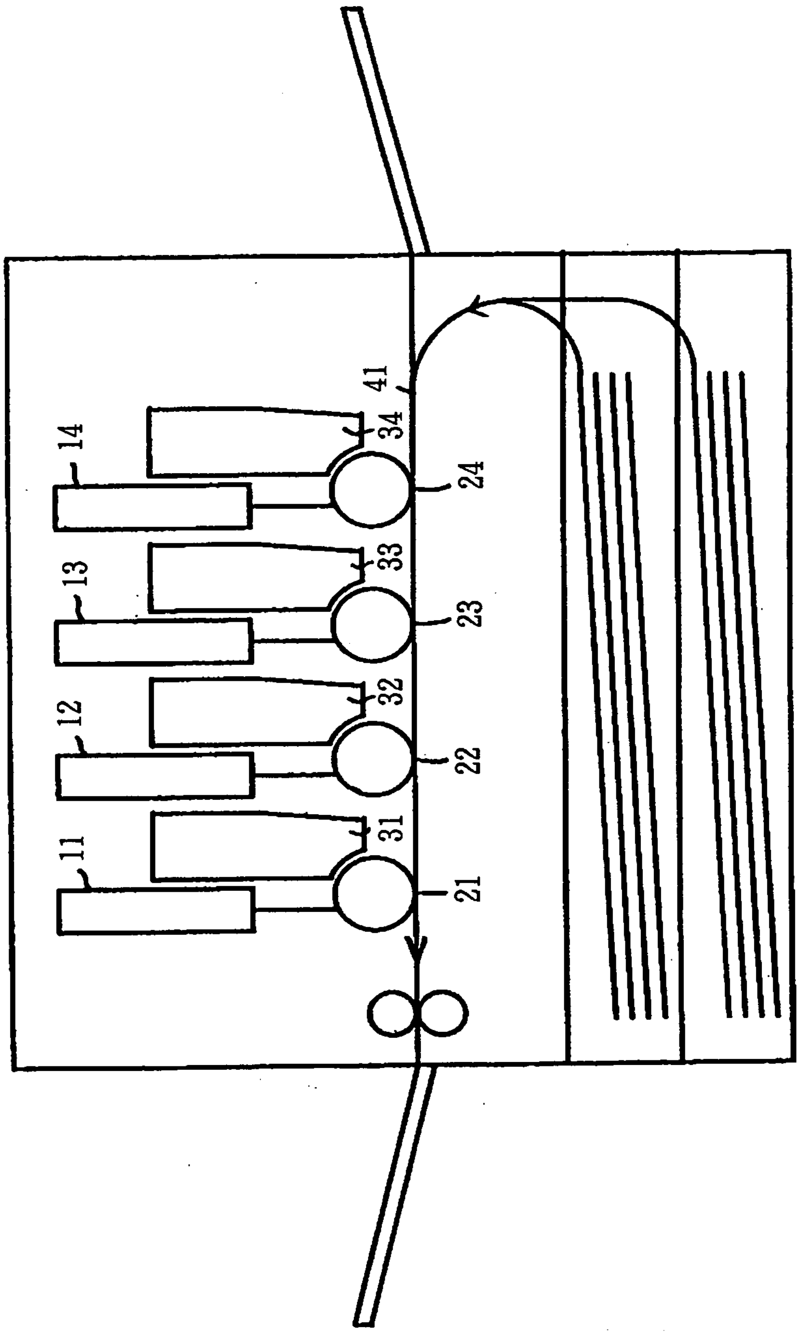
【図１】　Fig. 1



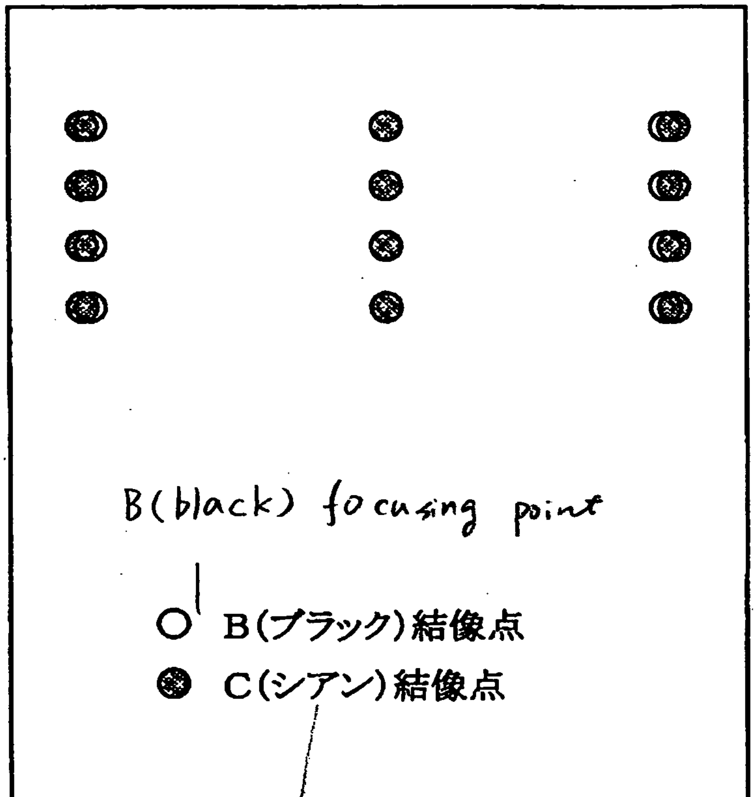
【図２】 Fig. 2


Laser A focusing point
○ Aレーザー結像点
● Bレーザー結像点
Laser B focusing point

【図３】 Fig. 3

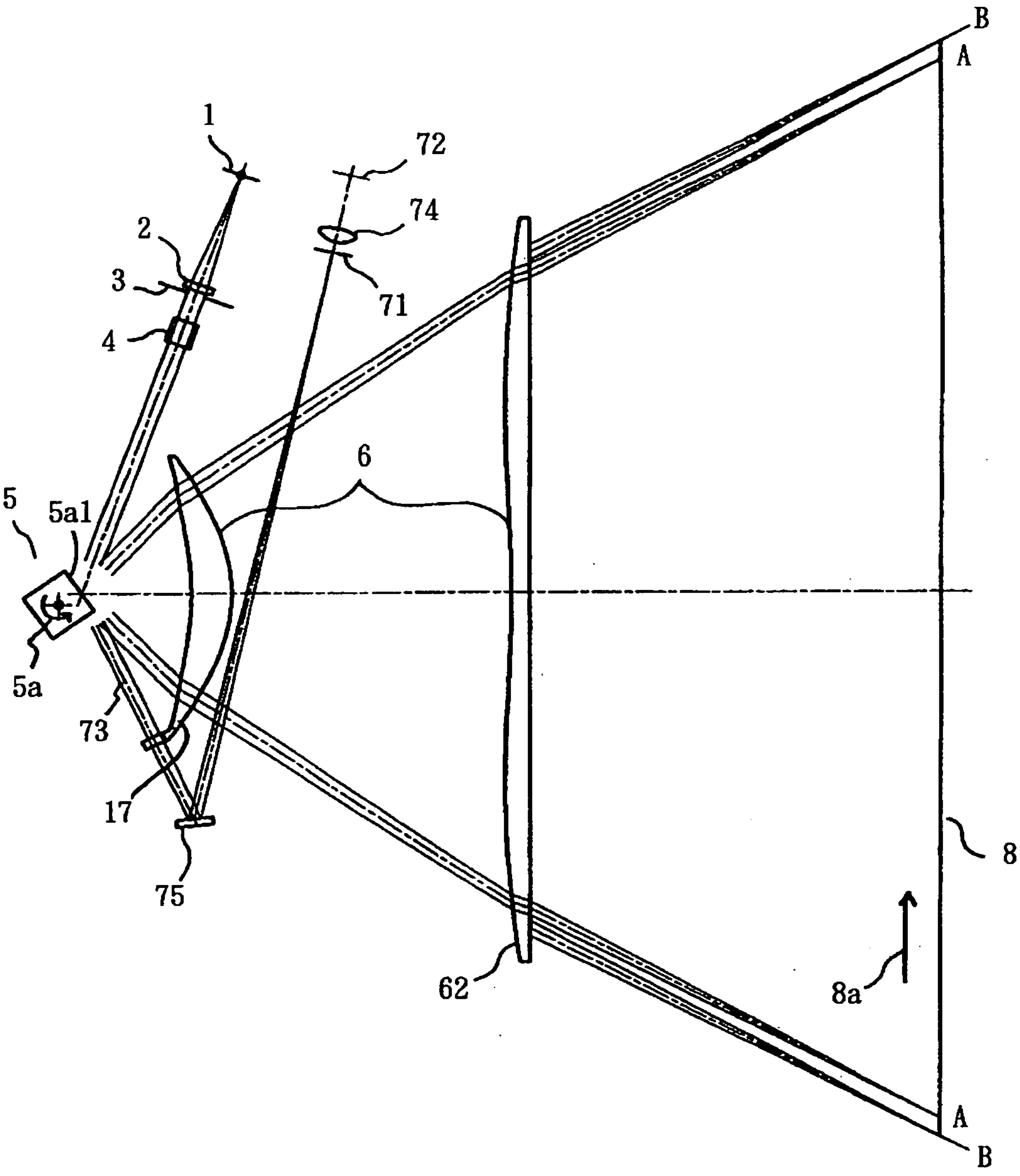


【図４】 Fig. 4

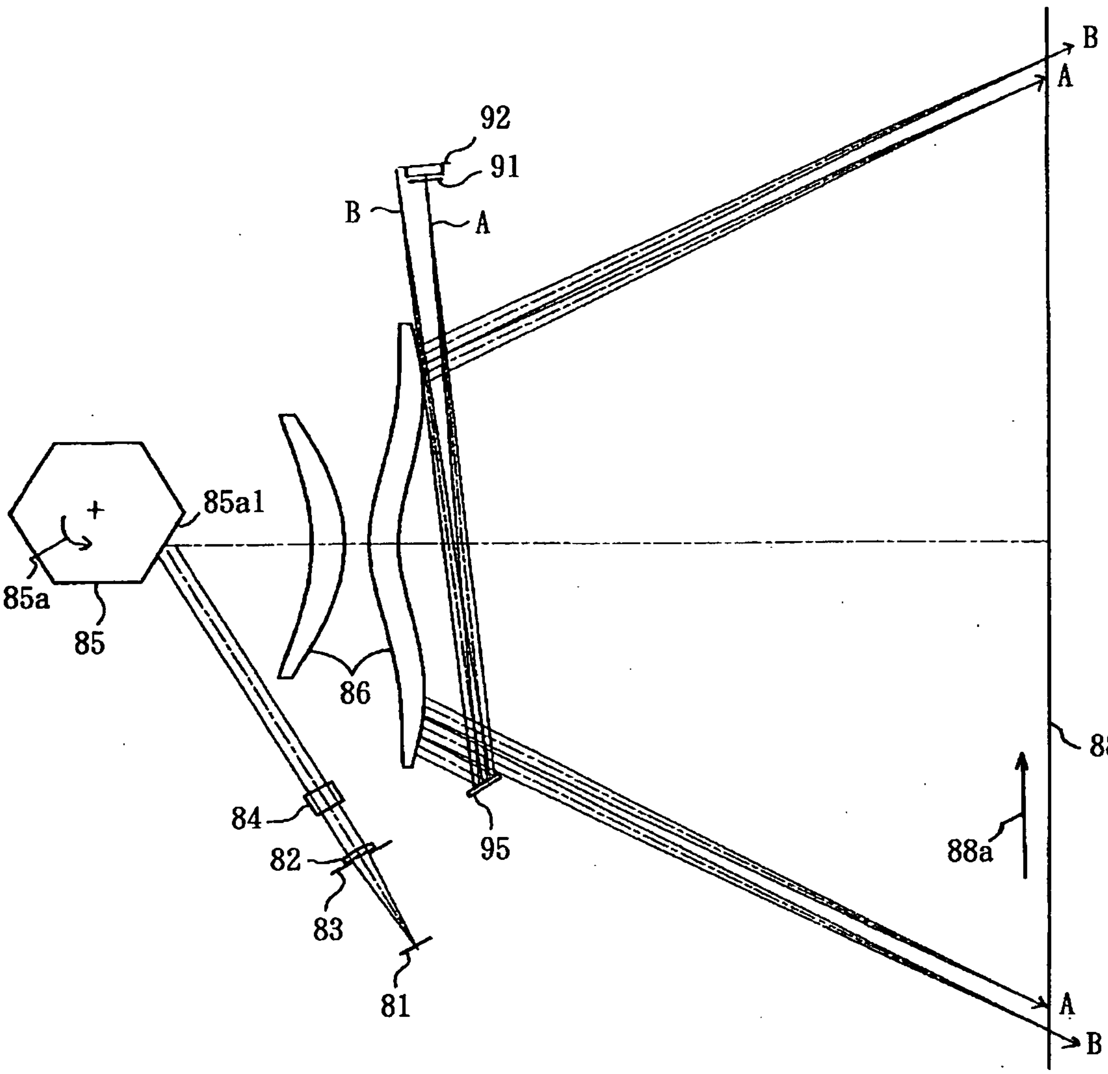


C (cyan) focusing point

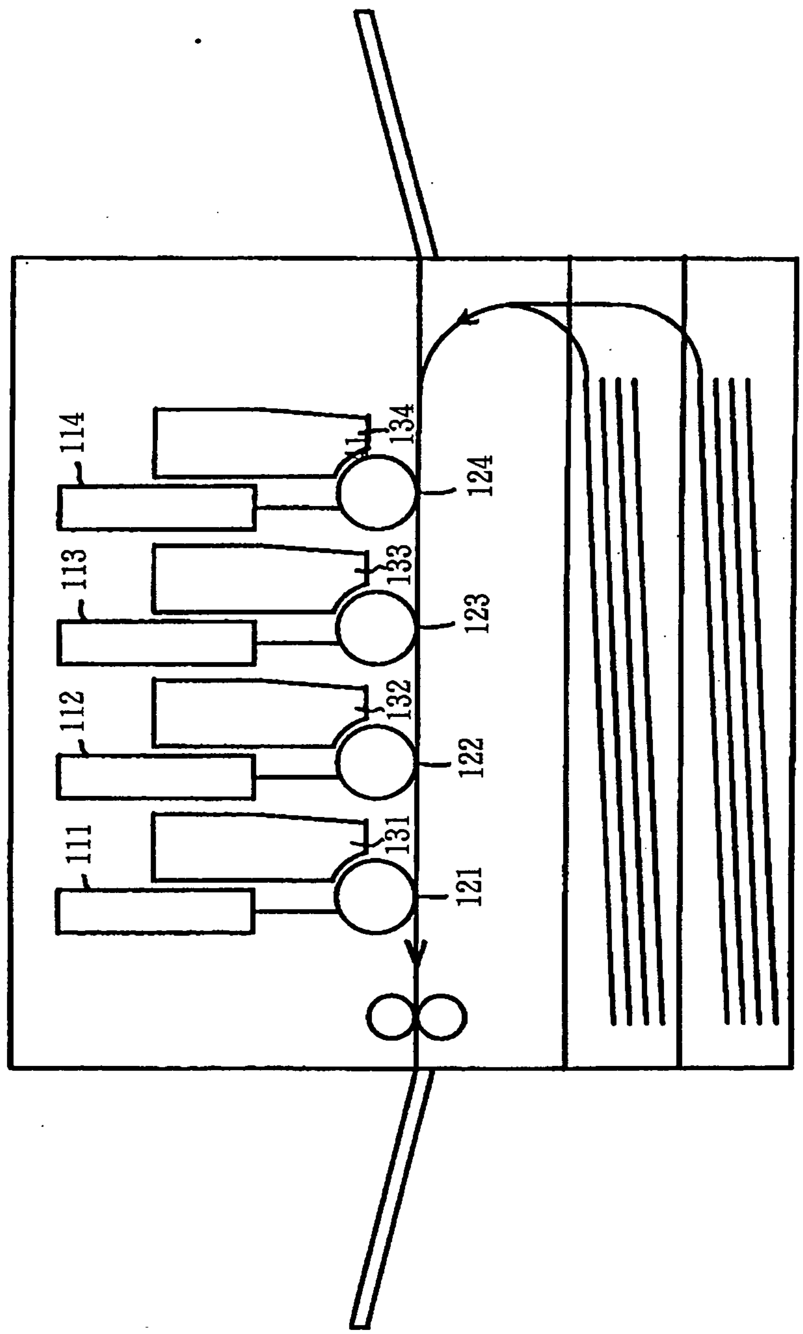
【図５】 Fig. 5



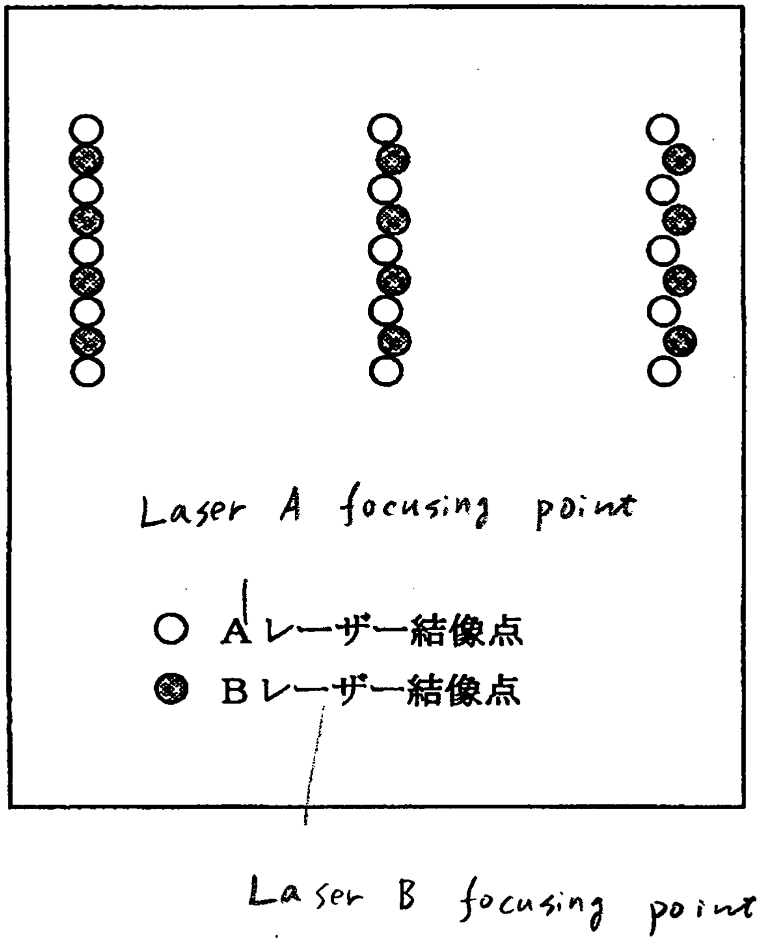
【図６】 Fig. 6



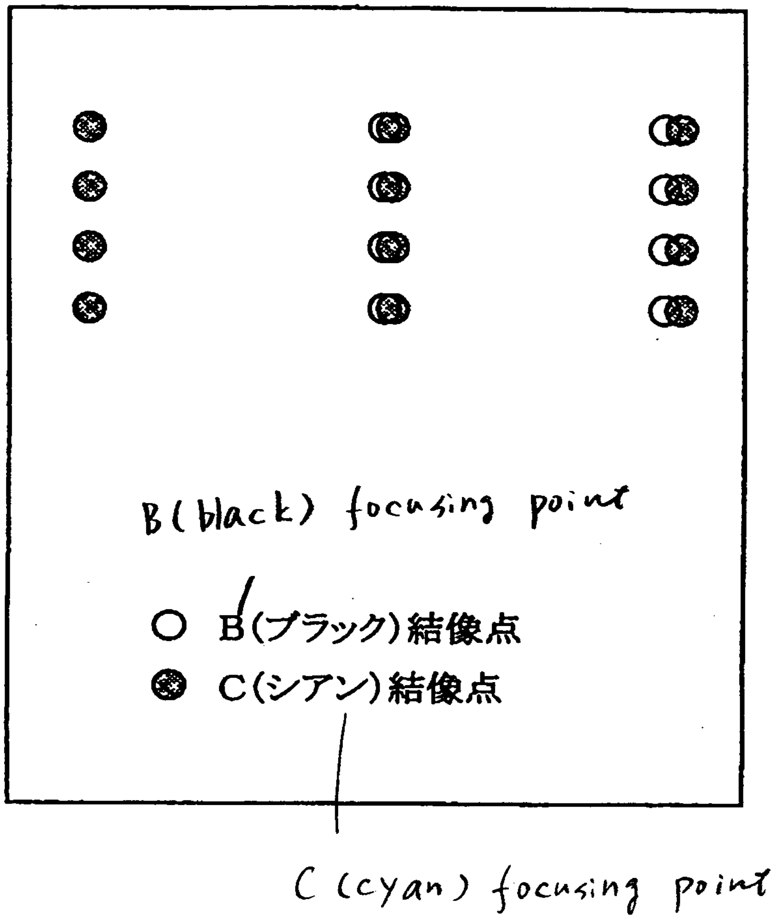
【図７】　Fig. 7



【図８】　Fig.8


Laser A focusing point
○　Ａレーザー結像点
●　Ｂレーザー結像点
Laser B focusing point

【図９】　Fig. 9


B (black) focusing point
○ B（ブラック）結像点
● C（シアン）結像点
C (cyan) focusing point

[Name of the Document] Abstract

[Abstract]

[Problem(s)] It is to obtain a multibeam scanning optical apparatus and a color image forming apparatus with less jittering or deviations of registration having a simple configuration.

[Means for Solving the Problem(s)] A multibeam scanning optical apparatus leads a plurality of light beams modulated and emitted independently relative to each other from a light source 1 having a plurality of light beam emitting sections and scans a surface to be scanned 8 by a plurality of the light beams, wherein the timing of scanning in the main scanning direction is controlled at or near the center of the scanning width in the main scanning direction on the surface to be scanned.

[Elected Drawing] Fig. 1

RECOGNITION · ADDITIONAL INFORMATION

Patent Application No.	Japanese Patent Application No. 2000-063399
Reception No.	50000273059
Name of the Document	Patent Application
Officer in Charge	Senior Officer in the 1st 0090
Data	March 13, 2000

<Recognition Information · Additional Information>

[Applicant]

[Identification No.]	000001007
[Domicile or Residence]	3-30-2, Shimomaruko, Ohta-ku, Tokyo
[Name]	CANON KABUSHIKI KAISHA

[Attorney] Offeror

[Identification No.]	100086818
[Domicile or Residence]	Takanashi Patent Office 9-23-301, 2-chome, Jiyūgaoka, Meguro-ku, Tokyo
[Name]	YUKIO TAKANASHI

2000-063399

Applicant s Information

Identification No.	[000001007]
1. Date of Change:	August 30, 1990
(Reason of Change)	New Registration
Address:	3-30-2, Shimomaruko, Ohta-ku, Tokyo
Name:	CANON KABUSHIKI KAISHA

2000-3027117